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Tick Infection of *Caiman crocodilus fuscus* at the Hidroprado Hydroelectric Dam in Colombia: New Records, Parasite Prevalence, and Blood Loss Rate

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Abstract. The main goal of this research was to identify the hard ticks (Acari: Ixodidae) found in 10 individuals of spectacled caiman (*Caiman crocodilus fuscus*) from 349 individuals captured at the Hidroprado hydroelectric dam in the Department of Tolima, Colombia. Parasite prevalence was 2.9%. A total of 40 ticks were collected and two species identified: *Amblyomma dissimile* (n = 39) and *Rhipicephalus sanguineus* (n = 1). This is the second record of *A. dissimile* in *C. crocodilus* in Colombia and the first record of *R. sanguineus* in crocodilians. The natural infection of *C. c. fuscus* by *A. dissimile* establishes this species as a host in the life cycle of this tick. Similarly, parasitism by *R. sanguineus* indicates *C. c. fuscus* as a potential host for this tick, which is important since it is associated with domestic animals and has a high potential for transmission of zoonotic diseases. Our results highlight the parasitic relationship between ticks and one of the most resistant wild vertebrates: caimans. The prevalence, although not high, establishes the potential of ticks to parasitize different species and to be a vector of diseases for new groups of hosts.

Keywords. Acari; Crocodylia; Ectoparasites; Hard ticks; Ixodidae; Parasitism.

INTRODUCTION

Ticks are transitory, hematophagous parasites that feed on mammals, birds, amphibians, and reptiles with environmental phases (oviposition and molt) and intermittent parasitic phases on the host during reproduction and feeding (Polanco-Echeverry and Ríos-Osorio, 2016; Luz et al., 2018). During the parasitic phases, they are of great importance because they cause ulcerative damage in the epithelium due to mechanical action, mild to severe anemia due to blood-sucking, toxic effects due to enzymes and neurotoxins present in saliva and, transmission of enzootic and zoonotic pathogens (Cortés-Vecino, 2011; Manzano et al., 2012; Oteo Revuelta, 2016; Cabezas-Cruz et al., 2018). The risk of exposure to ticks increases the vulnerability of animals to disease, generating pathologies that can reduce the parasitized population if individuals have not developed immune responses against them (Wikel, 1984).

Ticks are only occasionally found in crocodiles because they are not their habitual hosts (Huchzermeyer, 2003). However, tick infestations have been reported in 11 crocodilian species. Kwak et al., (2019) suggests there is a certain level of ecological overlap (water edge) between crocodilians and ticks where interactions between them would be facilitated. Crocodilians have a highly effective immune system (Siroski et al., 2009, 2013; Zimmerman et al., 2010), which makes it difficult to observe symptoms that are directly related to parasitism and highlights the need to broaden knowledge of the interactions between crocodiles and ticks and monitor the health of individuals in nature.

Currently, in *Crocodylus* Laurenti, 1768, *Paleosuchus* Gray, 1862 and *Caiman* Spix, 1825 genera, 21 records of ticks of the genus *Amblyomma* Koch, 1844 have been made, with identification of seven species: *A. dissimile* Koch, 1844 (Rainwater et al., 2001; Pietzsch et al., 2006, Lima and Gianizella, 2015; Charruau et al., 2016; Witter et al., 2016), *A. rotundatum* Koch, 1844 (Peralta et al., 1995; Morais et al., 2010; Rodríguez-Vivas et al., 2016; Witter et al., 2016; Acosta et al., 2019), *A. grossum* (Pallas, 1772) (Huchzermeyer, 2003), *A. humerale* Koch, 1844 (Labruna et al., 2005; Witter et al., 2016), *A. mixtum* Koch, 1844 (Rodríguez-Vivas et al., 2016); *A. exornatum* Koch, 1844 (Schwetz, 1927; Burridge, 2001; Huchzermeyer, 2003; Tellez, 2014) and *A. cordiferum* Neumann, 1899 (Kwak

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et al., 2019). In Colombia, only *A. dissimile* (one male and one female) has been recorded in *Caiman crocodilus* Linnaeus, 1758 at Caribbean region (Santodomingo et al., 2018).

The main objectives of this work were to identify the hard ticks (Acari: Ixodidae) found in the spectacled caiman, *Caiman crocodilus fuscus* (Cope, 1868), captured at the Hidroprado hydroelectric dam in the Department of Tolima, estimate parasite prevalence, and identify the risk of blood loss through blood sucking by ticks, considering the approximate blood consumption of ticks in the parasitized individuals.

MATERIALS AND METHODS

Study area

This study was undertaken at the hydroelectric dam of the Prado River (Hidroprado), in southeastern Department of Tolima, Colombia (03°45′N;74°50′W). Its area is 4,300 ha and has a warm climate (25–30°C) and rainfall of 700–2000 mm (Pizano and García, 2014). Hidroprado includes secondary forest patches, natural shrub vegetation, natural pastures used for extensive livestock farming, rural housing, private cabanas, and hotel infrastructure (Cortolima, Corpoica, Universidad del Tolima, 2006).

Collection and identification of ectoparasites

Given the size of the caimans (< 60 cm total length), the individuals were captured and released by hand or with the aid of a Pilstrom clamp or steel loop (Domínguez-Laso et al., 2011). Captured caimans were carefully examined for ectoparasites and the lesions they caused. The areas of the body where the ticks were distributed were recorded and photographed and ticks were extracted manually using a blunt-tipped forceps to ensure the extraction of complete gnathosomes (oral portions). Ticks were stored in jars with 100 mL of Hood's solution (95 mL 75% ethanol, 5 mL glycerin) for subsequent taxonomic and morphological identification at the parasitology laboratory of the Facultad de Medicina Veterinaria y Zootecnia of the Universidad Cooperativa de Colombia, Ibague-Espinal. The ticks were identified with the aid of a Leica EZ4® stereoscope and a Leica DM300® microscope and taxonomic keys to the ticks of the family Ixodidae (Barros-Battesti et al., 2006; Martins et al., 2014; Andreotti et al., 2016).

Parasite prevalence and blood loss rate

To estimate parasite prevalence, we calculated the proportion of captured *Caiman crocodilus fuscus* that were positive for ticks. To estimate the blood loss rate due to ticks, we considered the following parameters: (1) Blood volume of parasitized individuals based on the percentage of blood relative to live weight: Fleming and Fontenot (2014) determined this to be 3.5–5.5% in crocodilians, and we assumed the highest value (5.5%, expressed in mL) in order to avoid underestimating blood volume (Total blood volume = live weight of the animal × 0.055); (2) Daily consumption of blood by ticks: For *Amblyomma americanum* (Linnaeus, 1758), Koch and Sauer (1984) determined that nymphs and males consume 0.00135 mL/d and adult females consume 0.80 mL/d. We used these values because information this species is part of the same tick genus. (Daily consumption of blood = number of ticks × blood intake of tick nymphs, males, or females) and (3) The maximum volume of blood that can be extracted without significant health impacts: Blood extraction greater than 10% of total blood volume can result in hypovolemic shock in acute cases and anemia in chronic cases (Fleming and Fontenot, 2014). Therefore, we propose that there is no health risk when blood consumption of all ticks is less than 10% of the total blood volume and risk when blood loss exceeds 10% (maximum volume of blood loss = live weight of the animal × 0.1). We employed 10% as our criterion for health risk from blood loss because the spectacled caiman captured were small (25–60 cm), and at this stage they are more vulnerable to loss blood.

RESULTS

A total of 349 spectacled caimans were captured throughout the Hidroprado hydroelectric dam, among which ticks were observed in 10 individuals ranging in size from 25–60 cm in total length. As such, the estimated prevalence of tick parasites in *C. c. fuscus* was 2.87%. A total of 40 ticks were collected, of which 37 were adults and 3 were nymphs. Two species were identified: *Amblyomma dissimile* (29 females and 7 males; Fig. 1) and *Rhipicephalus sanguineus* (Latreille, 1806) (1 female; Fig. 2). The 3 nymphs were identified as *Amblyomma* sp. due to the lack of specific taxonomic keys and incompletely developed morphological characteristics, which hindered microscopic identification (Lah et al., 2016). The ticks were distributed as follows: 20 ticks on the ventral part of the hind limbs (Fig. 3E); 5 in the axilla (Fig. 3G); 4 on the ventral part of the lower jaw (Fig. 3B); 4 at the base of the tail (Fig. 3C, 3I); 2 in the ear (Fig. 3D); 2 on the neck (Fig. 3F); 1 on the lateral portion of the lower jaw (Fig. 3D); 1 on the lower left eyelid (Fig. 3H); and 1 on the dorsal part of the left hind limb (Fig. 3A).

Regarding risk to individuals due to blood loss by ticks, the results indicate that three individuals presented no risk (Table 1). Those individuals were each parasitized by a single tick, with resulting blood consumption less than 10% of total blood volume. In contrast, seven individuals were at risk, since blood consumption was 13–

Table 1. Risk from blood loss in *Caiman crocodilus fuscus*. LT = Total Length; VS = total blood volume; G = total number of ticks; H = females; M-N = males and nymphs; CSTG = blood intake of total ticks.

Id	LT (cm)	Weight (g)	VS (mL)	Ticks		CSTG (mL)	Criterion risk of blood loss		Risk from blood loss
				H	M-N		No-Risk (mL)	Risk (mL)	
1	25	70	3.9	2	3	1.604	0–0.4	> 0.4	Risk
2	34	150	8.3	2	0	1.600	0–0.8	> 0.8	Risk
3	33	130	7.2	2	1	1.601	0–0.7	> 0.7	Risk
4	31	110	6.1	1	0	0.800	0–0.6	> 0.6	Risk
5	31	112	6.2	2	0	1.600	0–0.6	> 0.6	Risk
6	38	265	14.6	1	0	0.800	0–1.5	> 1.5	No-Risk
7	37	250	13.8	1	0	0.800	0–1.4	> 1.4	No-Risk
8	42	350	19.3	1	0	0.800	0–1.9	> 1.9	No-Risk
9	60	614	33.8	17	6	13.608	0–3.4	> 3.4	Risk
10	33	120	6.6	1	0	0.800	0–0.7	> 0.7	Risk

40% of the total blood volume. In the medical review, we observed that eight individuals showed no clinical signs of disease or lesions. However, two individuals exhibited lesions due to the mixed action of the ticks (mechanical and blood sucking). One individual with a tick adhered to the lower left eyelid was observed with inflammation of the eyelid margin, although no infection or involvement of the eye or the nictitating membrane was observed (Fig. 4A). The second individual exhibited an irregular skin lesion 0.8 mm wide in the middle area of the neck (left side) with loss of dermis and epidermis resulting from the bite of an engorged adult female (Fig. 4B).

DISCUSSION

Ticks were collected from *Caiman crocodilus fuscus* in areas with patches of secondary forests, under anthropic influence, and high density of domestic animals with free access to water at the Hidroprado hydroelectric dam. Contact between domestic and wild or synanthropic species increases the opportunity for ticks to infect a great diversity of potential hosts, creating new opportunities for dispersion of infectious agents (Estrada-Peña and De la Fuente, 2014; Cable et al., 2017; Young et al., 2017). The low prevalence of ticks in spectacled caimans at this locality suggests that infection is opportunistic. *Rhipicephalus sanguineus* is a parasite with preference for domestic mammals; however, we observed an engorged female parasitizing an individual of *C. c. fuscus,* indicating that *R. sanguineous* is a potential ectoparasite of wildlife.

Rhipicephalus sanguineus is a cosmopolitan species and one of the main vectors of rickettsiosis (*Rickettsia conorii* Brumpt, 1932; and *R. rickettsia* Brumpt, 1922), anaplasmosis (*Anaplasma platys* Harvey et al., 1978 and *A. phagocytophilum* [Foggie, 1949]), *Ehrlichia canis* (Do-

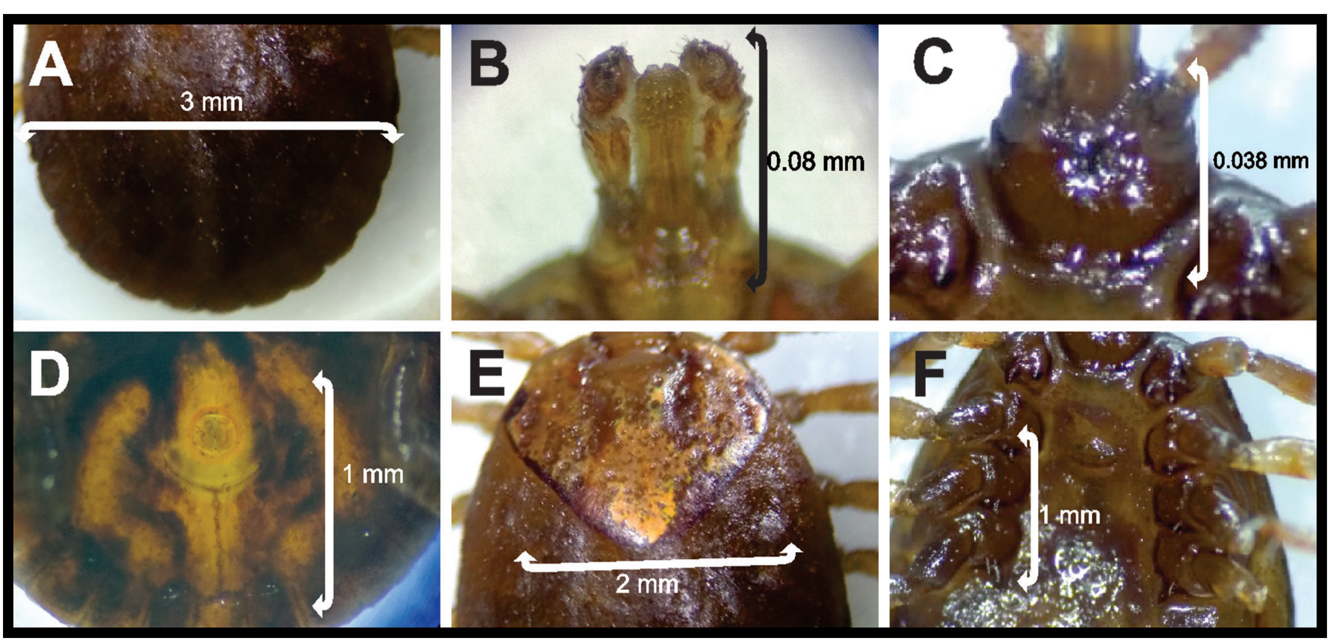

Figure 1. *Amblyomma dissimile.* **(A)** Presence of festoons. **(B)** Dentition (3/3). **(C)** Subtriangular capitulum. **(D)** Posterior anal groove. **(E)** Ornamented dorsal scutum. **(F)** Coxa I, II, III, and IV with 2 spurs present.

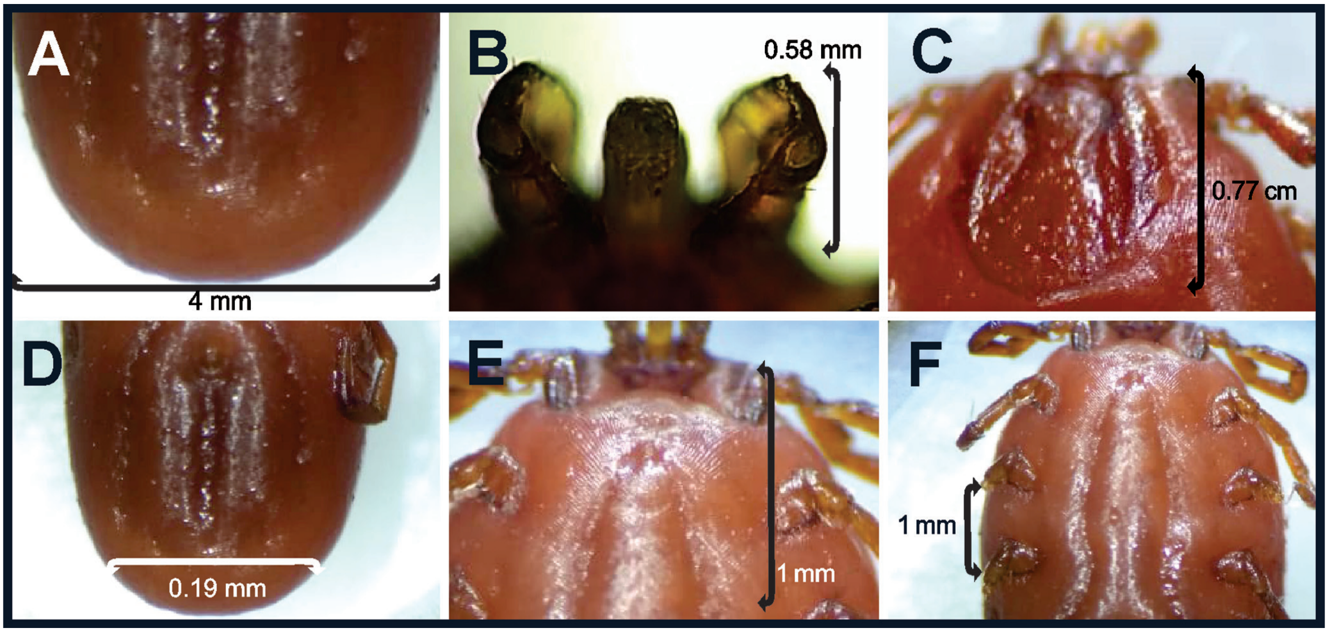

Figure 2. *Rhipicephalus sanguineus.* **(A)** marginal groove. **(B)** Hypostome. **(C)** Scapular groove. **(D)** Anus. **(E)** Genital aperture. **(F)** Coxa I (with large spurs), coxa II, coxa III, and coxa IV with spurs short.

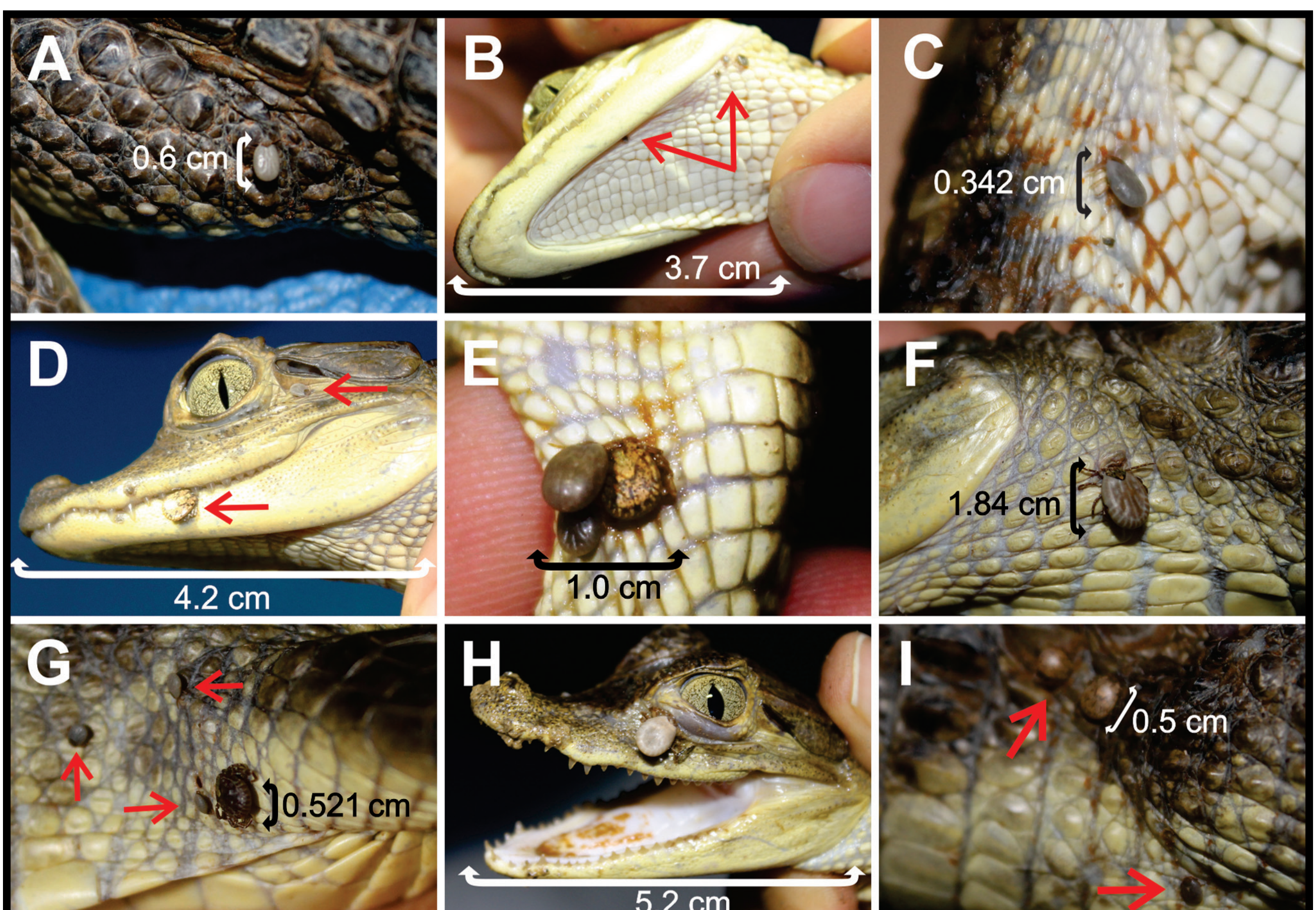

Figure 3. Corporal distribution of the ticks on spectacled caiman. **(A)** Dorsal part of left leg. **(B)** Lower jaw. **(C)** Ventral part of left leg. **(D)** Jaw and ear. **(E)** Ventral part of right leg. **(F)** Neck. **(G)** Right axilla. **(H)** Lower left eyelid. **(I)** Base of tail.

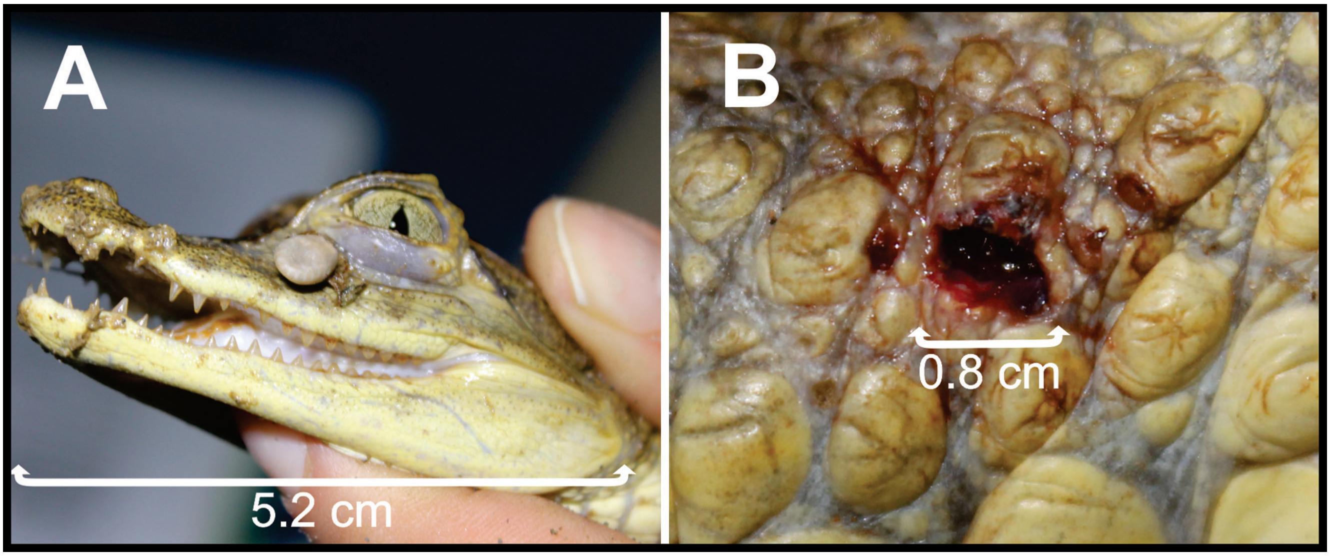

Figure 4. Cutaneous lesions due to the mixed action of the ticks. **(A)** Inflammation of the palpebral margin. **(B)** Irregular skin lesion.

natien and Lestoquard, 1935), *Hepatozoon canis* (James, 1905), and *Babesia canis* (Piana and Galli-Valerio, 1895) (Jongejan and Uilenberg, 2004). *Babesia* is an especially important hemoparasite because it causes morbidity and mortality in domestic animals, also affecting wild animals and, occasionally, humans, and is considered a pathogen of emerging zoonoses (Colwell et al., 2011). Mora (2009) recorded the presence of *Babesia* sp. in *Crocodylus acutus* (Cuvier, 1807) and *C. moreletii* (Duméril and Bibron, 1851) in captivity and nature but did not record any species of tick as a vector of this hemoparasite. However, Polanco-Echeverry and Ríos-Osorio (2016) indicated that the rate of infection by tick-transmitted *Babesia* is directly related to the abundance of the vector. *Rhipicephalus sanguineus* has been studied from the perspectives of biology (Dantas-Torres, 2010; Sanches et al., 2016; Labruna et al., 2017; Das et al., 2017), ecology (Dantas-Torres and Otranto, 2011; Gray et al., 2013; Szabó et al., 2013; Zemtsova et al., 2016), and epidemiology (Paz et al., 2010; Zemtsova et al., 2010; Socolovschi et al., 2012; Latrofa et al., 2014) due to its medical importance, but studies related to vector-parasite-host coexistence in the epidemiological chain in reptiles are lacking.

Reptiles and amphibians are the natural hosts of *Amblyomma dissimile* (Voltzit, 2007), but this species has also been reported to parasitize mammals, birds, and humans (Guglielmone and Nava, 2006; Guzmán-Cornejo et al., 2011; Scott and Durden, 2015). *Amblyomma dissimile* is a potential vector of *Ehrlichia ruminantium* (Cowdry, 1925), the causal agent of hydropericardium in cattle and other ungulates (Peter et al., 2002). Kiel et al. (2006) reported the infection of *Bitis gabonica* Duméril et al., 1854 with an attenuated species of *E. ruminantium* that has adapted to infect reptiles. Further, *A. dissimile* is a potential vector of *Rickettsia* sp. strain colombianensi (Miranda et al., 2012), *R. bellii* Philip et al., 1983, *R. monacensis* Simser et al., 2002, and *R. tamurae* Fournier et al., 2006, emergent zoonotic pathogens with clinical and health importance. *Amblyomma dissimile* has been reported in *Crocodylus acutus, Cr. moreletii, Caiman crocodilus* (Linnaeus, 1758) and *Ca. c. chiapasius* (Bocourt, 1876) (Rainwater et al., 2001; Pietzsch et al., 2006; Lima and Gianizella, 2015; Charruau et al., 2016; Witter et al., 2016; Santodomingo et al., 2018). Although the role of crocodilians in the cycles of enzootic diseases is not clear (Charruau et al., 2016), *A. dissimile* could play a role as a reservoir in the maintenance of rickettsiae in reptile populations (Jongejan, 1992).

Clinically, the skin lesions found in spectacled caimans in the present study do not represent a health risk; however, in adverse environmental conditions and stress, lesions or complex skin infections can cause weakness and enable secondary infections (Huchzermeyer, 2003; Merchant and Britton, 2006). An important aspect to keep in mind is that in wild crocodiles it is difficult to observe symptoms that are related to ectoparasites or parasitemia.

Chaeychomsri et al. (2016) determined that crocodiles are capable of producing and replacing erythrocytes and hemoglobin at normal levels in one week, which allows them to lose approximately 25% of the total blood volume without a negative effect on health. However, that value was obtained under experimental conditions in individuals of *Crocodylus siamensis* Schneider, 1801 with an average weight of 27 kg and 191 cm total length. We employed 10% as our criterion for health risk from blood loss because the spectacled caiman captured were small (25–60 cm), and in this stage they are more vulnerable to blood loss.

Our results showed that blood consumption by ticks at the Hidroprado hydroelectric dam could put spectacled caimans at risk of regenerative anemia, which depends directly on the size of the specimens and the extent of the parasitic infection, with the smallest individuals being most vulnerable due to their lower total blood volume. However, our criterion of health risk must be interpreted with caution because it is incomplete, given that blood sucking by *Amblyomma dissimile* persists for 24–32 d (Schumaker and Barros, 1994), and we do not take into account the capacity of blood generation in spectacled caimans.

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